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ABSTRACT

Computer-based interactive video (CBIV), a hypermedia system that uses the power of the computer to support student interaction with various audio and visual media, can pose such problems for students as the potential for learner disorientation and cognitive overload. Intended to explore the applicability of Wittrock's generative learning hypothesis in the use of pictorial graphic organizers with CBIV instruction, this study tested three hypotheses: (1) that graphical views generated by the students themselves would have a greater effect on tests of learning and retention than would a final form version; (2) that both a participatory graphic organizer (PGO) and a final form organizer (FGO) would have a greater effect on recall than on retention; and (3) that the posttest scores for the two groups using the different types of organizer should correlate positively with measures of analytic reasoning and holistic processing. Subjects for the study were 32 nursing students using a CBIV program. One group of 16 completed the program using a participatory form of graphic organizer which required them to fill in blanks on the organizer. The other group of 13 completed the CBIV program using a final form version of the organizer which required that the students only read and remember the information presented there. No significant difference was found between the two groups on the mean scores for posttest 1; while the PGO group did score slightly higher on posttest 1, the FGO group scored significantly higher on posttest 2; and correlations between the posttest mean scores and tests of analytic reasoning and holistic processing were generally small. It was concluded that although some support was found for the efficacy of generative organizers with CBIV, this study should be replicated with larger treatment groups, and that a "true" advance organizer should be included as one of the treatments. (29 references) (DB)

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The Generative Effects of Graphic Organizers with Computer-Based Interactive Video by Global and Analytic Thinkers

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Introduction

In the current information age, society is continually being influenced and reshaped by rapid and pervasive changes in technology. One exciting technology is computer-based interactive video (CBIV), a hypermedia system which combines the power of the computer to support student interaction with the richness of the various audio and visual media. In The major advantage of CBIV is that it can be adaptive and interactive (Jonassen, 1984) . He defines adaptive as "the ability to adapt or adjust the presentation sequence, mode or sign type to meet a variety of instructional requirements..." and interactive to mean "that the program engages the learner to participate in a variety of ways that utilize learner responses..." (p.21).

Hannafin (1989) views interactivity as providing one or more instructional functions from simple procedural control to causing differentiated levels of cognitive processing. These functions of interaction include confirmation of response, learner control of pacing and lesson sequencing, inquiry (glossaries and libraries), navigation, and elaboration, techniques which allow learners to combine known with to-be-learned lesson information.

Learner Disorientation

CBIV, while providing such flexibility, is not without problems. One is the potential for learner disorientation, the loss of one's sense of location or of the structure of the material. Navigation is the most commonly identified user problem in hypermedia (Jonassen, 1989). Learners can easily become lost and frustrated and may give up without acquiring any information from the program.

Another problem is cognitive overload. Jonassen (1989) also notes that the exponentially greater number of learning options available to learners places increased cognitive demands upon learners that they are often unable to fulfil. Tripp and Roby (1990) claim that disorientation leads to the expenditure of more

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mental effort to maintain a sense of orientation in the program which in turn reduces the mental resources available for learning.

Instructional Design for Hypermedia

How might one then mediate such disadvantages of hypermedia while capitalizing on its advantages? Effective browsers of hypermedia must be able to monitor their own comprehension of the information presented and select appropriate strategies that facilitate integrating and synthesizing information (Jonassen, 1989). If the material can be organized to replicate content or knowledge structures, then it would better provide the needed anchors for re-structuring the learner's knowledge. Jonassen (p.50) suggests that designers of hypermedia should be concerned with two aspects: the information model presented by the program and the user interface. The former describes how to organize or structure the information. The user interface describes the tools that the user has for accessing and navigating through the system. These include indexes and menus, cross-referencing and hypermaps. The latter provide a graphical view of the program structure, allowing the user to select a node on the hypermap and be taken immediately to that part of the program. The theoretical advantage of using a hypermap is that it should enhance the learner's structural knowledge (the knowledge of interrelationships between ideas) of the information in the program.

Instructional Organizers

One approach to enhance structural knowledge is the use of instructional organizers. Tripp & Roby (1990) suggest a traditional strategy, the advance organizer (Ausubel, 1960, 1963). Other related organizational approaches include the structured overview graphic organizer (Barron, 1969) and the pictorial graphic organizer (Hawk, McLeod & Jonassen, 1985), both derivatives of the advance organizer. These both resemble the hypermap and could potentially be used for navigation.

All three organizers are designed to relate the material-to-be-learned to the learner's existing cognitive structure to facilitate learning and retention. But are they effective with CBIV? Extensive research on advance organizers has produced a morass of conflicting results. Several reviews have been critical (Barnes & Clawson, 1975, Hartley & Davies, 1976, Macdonald-Ross, 1978, McEneany, 1990), while others have been supportive (Lawton & Wanska, 1977, Mayer, 1979a, 1979b, Luiten, Ames & Ackerson, 1980, Stone, 1984). Overall, advance organizers appear to have a modest effect upon learning and retention (Kenny, 1990). While noting far fewer research results, Kenny also found a modest effect upon learning and retention for structured overview and pictorial graphic organizers.

The few studies of organizers with CBIV-based instruction have focused on the advance organizer. Carnes, Lindbeck & Griffin (1987) reported no significant differences for advance organizers with a computer-based physics tutorial. Krahn & Blanchaer (1986) found a statistically significant difference in favor of advance organizers in a computer-based medical simulation but assessed learning with a very small immediate recall test (six questions). Theory holds that an advance organizer is unlikely to assist immediate recall and should be expected to have its strongest effect on retention (Mayer, 1979a, 1979b). Since forgetting is likely to occur between testing and re-testing, a group receiving an

advance organizer treatment should outperform another group on a retention test but that there should be no difference (or superior performance for another form of treatment) on a test of immediate recall. Research results have tended to support this assertion (Luiten, Ames & Ackerson, 1980, Stone, 1984, Kenny, 1990).

Tripp & Roby (1990) report the use of an advance organizer with a Japanese-English hypertext-based lexicon. Half the group using the advance organizer also received a visual metaphor. It was speculated that a statistically significant negative effect for the interaction between the two techniques may have negated any effect for the advance organizer.

Generative Learning

Pictorial and structured overview graphic organizers both appear to be most effective when presented in participatory form, that is, to be filled in or constructed by the learner (Kenny, 1990). This may occur because "the more generative the nature of student participation, the more likely it is that transfer and higher level learning will be affected" (Hawk, McLeod & Jonassen, 1985, p.179). Thus, Wittrock's (1974) generative learning hypothesis may provide a stronger basis for explaining the effectiveness of these techniques than does advance organizer theory. Wittrock claims that "it is the learner's interpretation of and processing of the stimuli, not their [the stimuli] nominal characteristics, which is primary" (p.88). In more simple terms, learners must construct their own meaning from teaching (Wittrock, 1985). Doctorow, Wittrock & Marks (1978) indicate that this involves not only generating meaning but overt activities as well; such as, generating associations among words, generating pictures, etc.

Hypotheses

This study was intended to explore the applicability of Wittrock's generative learning hypothesis in the use of pictorial graphic organizers with CBIV instruction. It was hypothesized that a participatory form of pictorial graphic organizer would have a greater effect on tests of learning and retention than would a final form version. The participatory form (PGO) requires the learner to fill in various blanks on the organizer while the final form version (FGO) presents the learner with a previously completed format. To complete a PGO, the learner must select information from the CBIV program and write it in the appropriate place on the organizer. When using an FGO, the learner is asked only to read and remember the information presented by the organizer. Thus, a PGO elicits a generative activity from the learner while an FGO, like an advance organizer, depends on its nominal characteristics for any effect.

Further, research has tended to indicate that pictorial graphic organizers, unlike advance organizers, have a greater facilitative effect on immediate recall than retention (Kenny, 1990). Most studies, however, used the generative PGO version. By way of confirmation, then, it was further hypothesized that both the PGO and the FGO would have a greater effect on immediate recall than on retention.

As an extension to a study on generative learning, Wittrock & Alesandrini (1990) also determined that high imagery text would cue learners' holistic ability (their ability to construct a whole from its parts) while instructions to engage

in verbal-analytic processing (constructing verbal analogies) would stimulate learners' analytic ability (the ability to abstract a common dimension across stimuli). The PGO and FGO each contain imagery (diagrammatic organization and pictorial elements) as well as to direct the learner to analyze and categorize information from the material-to-be-learned. Thus, both should supplement both holistic and analytic ability to improve learning. Therefore, it was hypothesized that the posttest scores for both treatments should correlate positively with measures of analytic reasoning and holistic processing.

Methods

Subjects

Subjects were 32 third year undergraduate nursing students at a major northeastern American university enrolled in an acute care nursing course. They had not previously been enrolled in the course. All were volunteers. Twenty-nine subjects completed all parts of the study.

Materials

An American Journal of Nursing CBIV program entitled "The Nursing Care of the Elderly Patient with Chronic Obstructive Pulmonary Disease" was used. It presented a case study which follows a patient from his arrival in hospital through admission to treatment and discharge. The graphic organizer treatments were developed by according to the procedures described by Hawk, McLeod & Jonassen (1985). They were identical except that the FGO was completed while various blanks were left to complete in the PGO.

Dependent Measures

Two versions of 24 question multiple choice posttest were used. These were criterion-referenced tests developed by the program's authors. Eighteen questions were used in the study since subjects were asked to complete only three of the four modules in the case study. Analysis of the questions revealed five questions requiring direct recall of information while 13 were near transfer items. Internal consistency reliability (Kuder-Richardson Formula 21) was 0.63 for Form A and 0.60 for Form B.

Independent Measures

As suggested by Wittrock & Alesandrini (1990), spatial holistic ability was measured by the Street Test (Street, 1931), a gestalt completion test which requires the learner to construct a spatial whole from a degraded figure which is pictured. The same measure of verbal-analytic ability was also used, the similarities subtest of the Wechsler Adult Intelligence Scale - Revised (WAIS-R) (Wechsler, 1981). It requires the learner to identify similarities between two objects. Responses are scored higher for symbolic-abstract similarities and lower for spatial-relational similarities.

Procedures

Subjects were randomly assigned to the two treatment groups - PGO or FGO. All subjects completed three of four modules in the program and were requested to read a version of the graphic organizer immediately prior to completing each module. The PGO treatment group also were asked to fill in the blanks in the organizer while doing the CBIV program or immediately after. The purpose of

the organizer was explained to each subject immediately prior to reading the first organizer and reiterated for each module.

Students completed the first posttest (immediate recall) after finishing the final module and the second (retention) posttest one week later. They did not have access to the program in between testings. This study used a counterbalanced design to eliminate any possible testing order effect.

The students completed the Street Test in class one week prior to the commencement of the study while the WAIS subscale was administered individually immediately before the commencement of the study.

Design

The results were analyzed using planned contrasts. Cohen (1990) suggests the use of a "more tolerant" (as liberal as 80%) confidence interval for the behavioral and social sciences. Since the purpose of this study was exploratory, the contrasts were calculated at the $p < .10$ level. However, as family-wise error is a concern when performing multiple tests, a modified version (Keppel, 1991) of Dunn's procedure was used to control for this effect at $\alpha_{FWplanned} = 0.30$, $\alpha_{planned} \leq .075$ level.

Cohen (1988, 1990) also recommends power analysis. While the research on pictorial graphic organizers has not been extensive to date, results indicate an average effect size of 1.54 for tests of immediate recall and of 0.86 for retention tests (Kenny, 1990). Based on these results, power was expected to be $(1 - \beta) > 0.98$ ($\beta < 0.02$) for the test of immediate recall and $(1 - \beta) > 0.66$ for the retention test ($\beta < 0.34$).

Results

Results for descriptive statistical data are displayed in Table 1. To test the first hypothesis, that the PGO group would outperform the FGO group in both tests of immediate recall and of retention, planned contrasts were calculated using one-tailed t-tests. Students in the PGO group obtained a higher mean score ($M = 13.5$) on Posttest 1 than did those in the FGO group ($M = 11.846$). The difference was not statistically significant: $t(50) = 1.097$, $p > .075$. However, students in the FGO group obtained a higher mean score ($M = 13.615$) on Posttest 2 than did those in the PGO group ($M = 13.438$). Again, the difference between the means was not significant: $t(50) = 0.572$, $p > .075$.

Table 1

Descriptive Statistics

	Posttest 1			Posttest 2	
	N	M	SD	M	SD
FGO	13	11.85	2.94	13.62	3.12
PGO	16	13.50	2.68	13.44	2.34

The second hypothesis stated that both the PGO and the FGO treatments would have a greater effect on immediate recall than on retention. Subjects in the PGO group obtained a slightly higher mean score on Posttest 1 ($M = 13.5$) than on Posttest 2 ($M = 13.438$). This difference was not statistically significant: $t(25) = 0.066$, $p > .075$. Students in the FGO treatment group, contrary to the hypothesis, scored substantially higher (1.769 points) on Posttest 2 ($M = 13.615$) than on Posttest 1 ($M = 11.846$). The difference was statistically significant: $t = 1.688$, $p < .075$.

Pearson r correlation coefficients are displayed in Table 2. The third hypothesis held that the mean posttest scores for both treatments should correlate positively with the mean scores on the WAIS similarities subscale and on the Street Test. While three of four correlation coefficients were positive, none were statistically significant. Further, the largest correlation, that between the Street Test and Posttest 2 means was negative (-.298). Nor was it statistically significant.

Table 2

Pearson r Coefficients

	Wais	Street Test
Posttest 1	0.066	0.133
Posttest 2	-0.298	0.024

Discussion

The first hypothesis predicted that students receiving the participatory, or more generative, form of pictorial graphic organizer (PGO group), would outperform, on average, those who received the final form version (FGO). Confirmation of this hypothesis would provide evidence that Wittrock's (1974) generative learning hypothesis could be applied to the use of instructional organizers with CBIV. Results indicated no significant effect in favor of the PGO treatment on the mean scores of posttest 1. While likely attributable to chance, it is interesting to note that the difference would have been significant at a more liberal level of $p \leq 0.15$. Cohen (1990), recommends using confidence intervals as high as 80%. However, a planned alpha of 0.15 would also result in a familywise error of 0.45. As well, there was no significant difference between the mean scores for the two treatments on posttest 2. They were virtually identical. To confirm that the PGO treatment acted in a generative fashion, one would expect an effect on retention as well as on immediate recall.

Further, there appeared to be strong confounding factors affecting treatment fidelity. Students in both treatment groups engaged in extraneous note-taking. Inspection indicated that the PGO treatment group took extra notes (beyond those required) on the back of 64.4% of the organizers while the FGO treatment group did so on 58.9% of their organizers. This note-taking may have constituted an additional, generative activity.

As well, many of the PGO group did not complete the PGO thoroughly. Examination of the PGO organizers revealed that 46.7% contained five or more uncompleted spaces, while 37.8% had ten or more spaces unfilled. It is questionable if these organizers proved an effective instructional treatment. Indeed, Hawk, McLeod and Jonassen (1985) indicate that the graphic organizer be reviewed as instruction progresses and that the instructor check students' organizers for misconceptions prior to any evaluation. Such review may have contributed strongly to past positive research results in favor of this technique. Even if one accepts a more liberal test of the null, it is difficult to determine if the difference in posttest 1 scores did indeed accrue from the generative organizer treatment.

The second hypothesis predicted higher mean scores for the posttest 1 than posttest 2 for each treatment as a result of forgetting. The results here were curious. The PGO treatment group scored slightly higher on posttest 1, but the difference was

not significant. The FGO group, however, scored nearly 2 points (on an 18 point test) higher on posttest 2. This result was statistically significant, thus ruling out chance as a likely alternate explanation. This is consistent with the theory (Mayer, 1979a, 1979b) that advance organizers can be expected to be more effective in facilitating retention and may indicate that the FGO acted as an advance organizer.

The third hypothesis predicted that both posttest mean scores should correlate with tests of analytic reasoning (WAIS-R Similarities subscale) and of holistic processing (Street Test). This hypothesis was not supported. Correlations were generally small and the most striking result indicated a negative relationship. It is probable that the organizers did not stimulate either type of ability although the variability of the small sample size may have been a factor as well.

Recommendations for Further Research

Although suggestive results were obtained indicating some support for the efficacy of generative organizers with CBIV, this was an exploratory study with a small sample size. The next logical step would be to replicate it with larger treatment groups. Further, to compare more clearly with advance organizer theory, a "true" advance organizer should be one of the treatments. Comparable results for advance organizer and final form pictorial graphic organizer treatments would provide clarification that the latter indeed act as advance organizers while a superior performance for the participatory pictorial graphic organizer would be strong evidence for generative learning theory.

Finally, students' participatory graphic organizer responses were not reviewed in this study prior to either posttest. If confirmation of correctness of response is a critical component of this technique, then provision of the organizer electronically, with periodic opportunities to review and compare responses, may improve its effectiveness.

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